



A Manual on Postharvest Handling of Tomato



Crops Division, Bangladesh Agricultural Research Council
Asian Food And Agriculture Cooperation Initiative

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Foreword

Tomato is an excellent source of vitamins, minerals and valuable antioxidants. Bangladesh produces substantial amounts of tomatoes every year. However, a considerable proportion of the harvested tomatoes are lost every year. Hence, improvement of postharvest handling is necessary to reduce loss and contribute to the nutrition security in the country. Postharvest research, training and extension are still inadequate in Bangladesh. Nonetheless, recently research and extension activities to minimize postharvest losses and maintain quality and safety of horticultural produce have been prioritized in the country. Adequate emphasis to be paid on the improvement of postharvest handling practices including harvesting, packaging, transportation and storage. However, there is paucity of user-friendly instruction manual on postharvest handling of horticultural crops in Bangladesh including tomato. I am very glad to know that BARC is going to publish a manual on Postharvest Handling of Tomato in Bangladesh with the financial support from the AFACI Post Harvest Project (Establishment of Network and Model Manual on Postharvest Technology of Horticultural Crops in Bangladesh). The manual elaborates the present status of postharvest practices in Bangladesh and how to improve the postharvest handling system so as to minimize loss and maintain quality and safety in supply chain. My firm belief is that the manual would be of great help for stakeholders in tomato supply chains including growers, traders and consumers. The manual will also be useful for the students, scientists, researchers and extension workers in relation to improved postharvest handling practices and will contribute to the expansion of tomato industries of the country.

I convey my sincere thanks to the authors and the scientists of BARC (Bangladesh Agricultural Research Council), BAU (Bangladesh Agricultural University), SAU (Sher-e-Bangla Agricultural University) and BARI (Bangladesh Agricultural Research Institute) who greatly contributed to bring out this piece of valuable document.



(Dr. Abul Kalam Azad)
Executive Chairman, BARC

Preface

Tomato is a highly nutritious fruit vegetable which is an excellent source of vitamins, minerals and antioxidant called lycopene. In Bangladesh, tomato is mainly grown in the winter season. Recently, some heat tolerant varieties have been developed which can be grown in summer. Tomatoes are grown all over the country. However, commercial production is concentrated in Rangpur, Rajshahi, Bogra, Comilla, Chittagong, Norshingdi and Jessore. Area, production and yield of tomato increased over the last several years. During 2012-13, 251 thousand metric tons of tomatoes were produced from 26 thousand hectares of land. Unfortunately, a considerable proportion of tomatoes are lost every year after harvest. The total estimated loss along the marketing channel is around 33%. Hence, improvement of postharvest handling is necessary to minimize loss and maintain quality and safety. Earlier research and training were mainly production-oriented. Postharvest research, training and extension were inadequate for long time. Nevertheless, postharvest research and training in terms of minimization of losses, maintenance of quality and safety in supply chain and value addition activities have been prioritized by the government of Bangladesh. The present initiative to publish "**A Manual on Postharvest Handling of Tomato in Bangladesh**" as part of the AFACI Post Harvest Project is aimed at elaborating the present status of postharvest practices in Bangladesh and how to improve the postharvest handling system so as to minimize loss and maintain quality and safety of tomato in supply chain.

This publication is possibly first of its kind in Bangladesh. It is not unlikely that there may have some ambiguities in the document. Any comments or suggestions on the contents would be highly appreciated for further improvement of the manual in future.

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We acknowledge with profound regard the following scientists for their contributions in preparing this manual:

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1. Cultivation System & Postharvest Procedure

1.1. Introduction

- Tomato ranks the 8th position among the vegetables grown in Bangladesh in terms of area and production.
- Presently around 251 thousand metric tons of tomatoes are produced from 26 thousand hectares of land.

1.2. Cultivation system

- Tomato is mainly grown in open field as a winter vegetable.
- Important varieties are BARI Tomato-2 (Ratan), BARI Tomato-14, BARI Tomato-15 and Roma VF.



Cultivation of tomato in open field in the winter season

- Some important hybrid varieties are Suraksha, Safal, Mintu, Udayan, etc.
- Some BARI developed heat tolerant varieties, such as BARI Hybrid Tomato-3, 4 and 8 are cultivated in summer under polytunnel.
- Optimum time of sowing of summer tomato is the month of May.
- Tomato is grown well at temperature ranged between 25-30°C day temperature and 15-20°C night temperature.
- Well drained, deep and fertile loamy soil is suitable for growing tomato.



Cultivation of summer tomato under polytunnel condition

- Seeds are to be sown in the seedbed during August-September for early cultivation; October for mid season cultivation; and December for late season cultivation.
- Seeds are sown in 3m × 1m size raised seedbed. Twenty to 22 such seedbeds are needed to grow tomato in one hectare of land.
- Before sowing, seeds should be treated with Vitavax @2g/kg to avoid seed borne diseases.
- Seed rate is 200 g/ha.
- Seedlings of 25-30 days old are to be transplanted with the spacing 60 cm × 50 cm.
- BARC (Bangladesh Agricultural Research Council) recommended fertilizer doses to be followed. Besides, fertilizer doses recommended by Vegetable Division of BARI as shown in the following table may also be followed:

Manure/ Fertilizer	Total amount	During land preparation	1st topdress 10 days after planting	2nd topdress 25 days after planting	3rd topdress 40 days after planting
Cowdung	10 ton	All	-	-	-
Urea	300 kg/ha	-	100 kg/ha	100 kg/ha	100 kg/ha
TSP	175 kg/ha	All	-	-	-
MoP	250 kg/ha	100 kg/ha	-	90 kg/ha	60 kg/ha

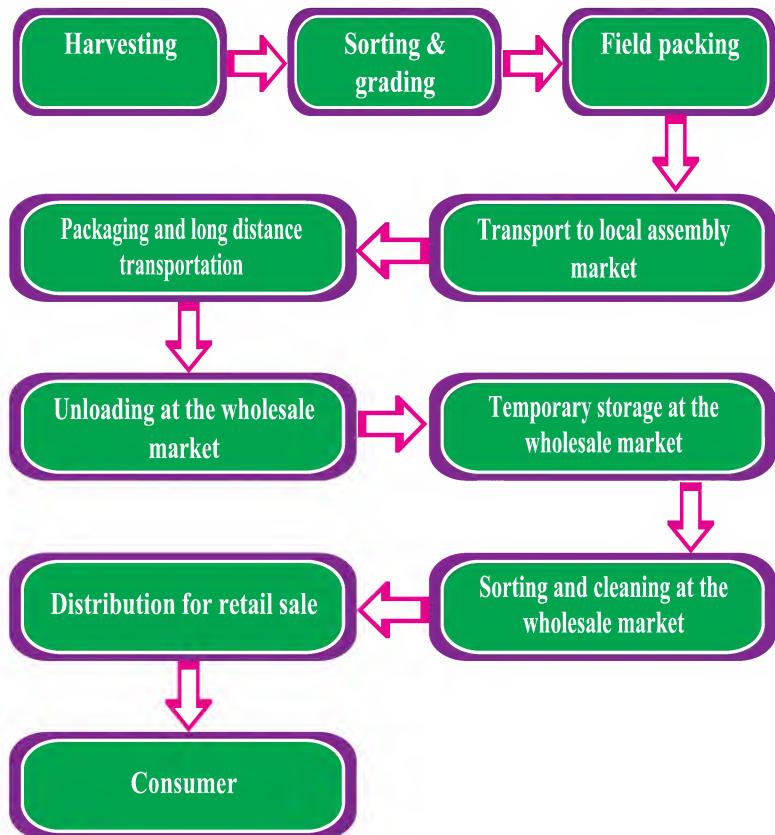
Above mentioned recommended doses of TSP, MoP and cowdung are to be mixed well and applied during final land preparation. In case of topdress of urea and MoP, these should be applied mixing well with soil 10-15 cm apart from plants

- Seedlings are to be planted in the late afternoon when scorching heat does not prevail. Light irrigation to be given just after planting.
- Sowing of summer tomato to be done during May-June.
- Standard intercultural operations to be practiced to grow tomato.
- Predominant insects are fruit borer, aphid, cutworm, mealy bug, thrips and white fly. The most serious diseases are tomato mosaic virus and wilt.
- Combination of integrated pest management (IPM) and chemical measure are practiced to control pests and diseases.
- Tomato becomes harvestable within 70-90 days after transplanting.
- Yield in winter season is 70-80 t/ha and in summer is 35-40 t/ha.

1.3. Postharvest handling steps of tomato

- Tomato reaches the hands of consumers through a number of intermediaries or middlemen.
- The main market actors are growers, small primary trader (Faria), large primary trader (Bepari), commission agent (Aratdar), wholesalers, retailers and consumers.

- The following postharvest handling steps are generally observed:

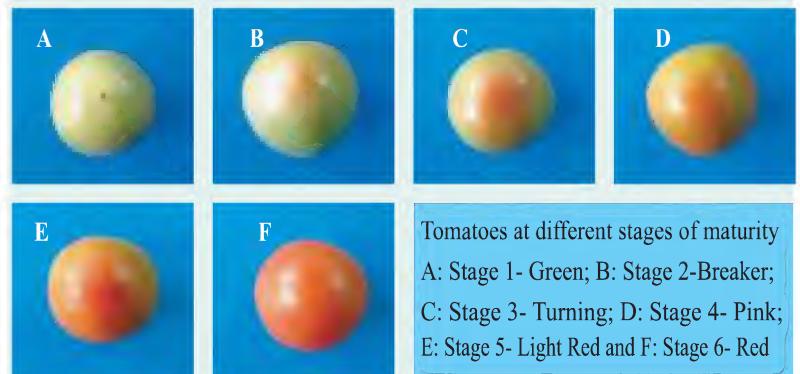


Postharvest handling steps for tomato in Bangladesh

2. Postharvest Handling of Tomato in the Field

2.1. Harvesting

- Changes in peel colour of tomatoes are widely practiced to determine its maturity at harvest.
- For table and market tomatoes both the loss of green colour and appearance of red colour are considered.



- Generally, there are six colour stages, namely 'Green' (mature but green), 'Breaker' (tinge of colour development; <10% coloured), 'Turning'(more green than red), 'Pink' (more red than green), 'Light Red' (trace of green), and 'Red'(full red).
- Tomatoes can be harvested at different stages of maturity depending on the intended use of the fruits.
- Tomatoes to be harvested at 'Breaker' stage for long distance transportation and storage purposes. Tomatoes to be harvested at 'Pink' stage for consumption in 2-3 days after harvest. Harvesting to

be done at ‘Light Red’ and ‘Red’ stages for immediate consumption and processing purposes, respectively.

- Plastic crates should be used as field containers during harvesting since crates are durable, reusable and can be cleaned easily.
- Harvested tomatoes are not to be left on the ground to avoid contamination by dirt, harmful micro-organisms or heavy metals.
- It is suggested not to use bamboo baskets to avoid bruising by the sharp edges of the baskets which causes rapid quality deterioration. Considering the existing reality, bamboo baskets can be used with proper lining materials like paper, foam or soft clothes to reduce damage during transportation.
- The harvesting tools and equipments should be disinfected with chlorinated water to minimize microbial contamination.



Harvesting of tomato at ‘Pink’ stage



Plastic crates are to be used as harvesting container

- Tomatoes to be harvested in a clear and sunny day.
- Suitable time of harvesting tomatoes is early morning when the dew drops disappear.

2.1.1. Measures for harvesting

- Care must be taken to avoid any damage or injury during harvesting.
- Market demands in terms of size, shape and maturity to be considered.
- Do not harvest immature tomatoes because they lack nutritional and eating qualities. Unfortunately, often this is practiced by some unscrupulous operators who try to fetch early markets by harvesting immature tomatoes followed by applying artificial ripening agent.
- Harvesting containers must be clean and free from rough edges to avoid damage and injury.
- The harvesters or pickers should be properly trained on harvesting methods and harvest maturity.
- Harvested tomatoes to be kept under shade to prevent heat and sun damage which reduce the rate of nutrient degradation.
- Only the insect and disease free tomatoes to be harvested.

2.2. Field packing

- Different types of packing materials, such as jute sacks, plastic net and bamboo basket can be used for field packing of tomatoes.
- The harvested tomatoes are to be primarily kept on a thick plastic sheet prior to packaging in plastic crates.
- The harvested tomatoes are to be packed in clean plastic crates, plastic buckets or plastic net bags.



Improved field packing of tomatoes in plastic crates

2.3. Transport from farm to packing shed/assembly market

- For local transportation, tomatoes are to be packed in plastic crates or bamboo baskets and quickly transferred to the packing shed or nearby assembly market.
- Paper, foam or cloth liners should be used, especially for bamboo baskets to minimize damage.
- Tomatoes are to be covered with clothes or papers during local transportation to prevent heat damage or avoid sunlight.



Presently practiced local transportation of tomato



Presently practiced local transportation of tomato

3. Postharvest Handling in Packing House

3.1. Pre-cooling

- Pre-cooling is an important postharvest practice which helps extend shelf life and maintain quality of tomato.
- Tomatoes to be brought to the packing shed of low temperature to remove field heat.
- The recommended pre-cooling temperature is 12.5°C.
- Forced-air cooling is the most effective practice to remove field heat prior to storage.
- In absence of structured packing shed with cooling unit, the growers are strongly suggested to keep harvested tomatoes under shade and cool place.

3.2. Sorting

- Sorting is the practice to remove produce that may cause a risk of shortening shelf life and microbial contamination.
- Sorting is practiced to remove tomatoes of the following categories:
 - ⇒ Contaminated tomatoes;
 - ⇒ Senescent tomatoes;
 - ⇒ Insect damaged tomatoes;
 - ⇒ Tomatoes with bruised skin;
 - ⇒ Tomatoes that are out of the acceptable quality grades.



Sorting of summer tomatoes in cool place of grower's house

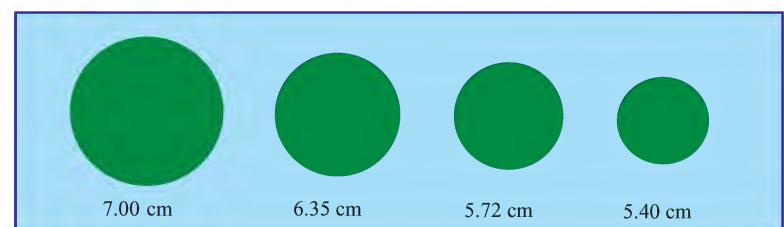
- Sorting should be practiced in the cool place of packing shed.
- In absence of structured packing shed, growers are suggested to perform sorting operation in a shady place of their field or in the cool place of their house to maintain postharvest quality.

3.3. Grading

- Grading is an important postharvest operation for enhanced marketing.
- Tomatoes can be graded on the basis of size and colour.
- Growers are suggested to grade tomatoes into large, medium and small sizes for the convenience of the buyers.

Table 1. USDA grading standard for tomatoes

Grade	Size in diameter (cm)	
	Minimum	Maximum
Small	5.40	5.79
Medium	5.72	6.43
Large	6.35	7.06
Extra large	7.00	-



Sizing ring for grading

- In Bangladesh, there is no standardized grading system but the grading system as suggested by USDA can be followed (Table 1).
- Sizing rings can be used to grade tomatoes manually into small, medium, large and extra large for enhanced marketing.
- In the developed countries, various computer assisted automatic sorting and grading machines are used to grade tomatoes according to size, shape, colour and surface defects.

3.4. Washing

- Washing provides customers with tomatoes that are attractive and clean with minimal risk of microbial contamination.
- Washing greatly improves postharvest quality and extend shelf life by removing dirt, adherences, external pathogenic structures, etc.
- The washed tomatoes are to be air dried prior to packaging and storage.
- In the case of severe dirt, tomatoes can be washed in chlorinated water for 20 minutes (100-150 ppm Cl).
- Apart from the use of various washing solutions, simple rinsing with clean cold water of potable quality could be useful to reduce surface dirt and adherences.

3.5. Packaging

- Proper packaging protects tomatoes from damage due to repeated handling during marketing.
- Properly designed package adds value and creates customers appeal.
- For local transportation, tomatoes to be packed in plastic crates.
- In absence of plastic crates, bamboo baskets can be used but sufficient paper or cloth liners should be used to minimize damage by the sharp edge of the basket.
- For long distance transportation, both traditional and improved packaging are practiced.
- For traditional packaging jute and plastic sacks are used which often results in high degree of spoilage due to compactness, vibration and heat generation.



Cloth and paper liners to minimize damage during transport



Traditional (left) and improved (right) bulk packaging of tomatoes

- For long distance transportation, plastic crates are most suitable to reduce damage and to maintain quality.
- Paper or plastic liners to be used inside the crates to minimize injury and weight loss.
- Packages must be intact and clean to prevent contamination, especially by microorganisms.

3.5.1. Measures for packaging

- Improved packages, such as plastic crates are to be used instead of the conventional bamboo made packages.
- Packages should be strong enough so as to withstand repeated handling.
- Packages should not be very large or voluminous.
- Packages should not be overloaded.
- Produce should not be held too tightly or too loosely to minimize damage.
- Packages should have ventilation holes to allow aeration (5% of the surface area per side).
- The packages should have label with farm logo and other relevant information for value addition and enhanced marketing.
- Do not use broken and dirty crates.

4. Transportation

- Transportation is the key to efficient marketing of any perishables.
- At the growers' level, tomatoes are transported by various local carriers like bicycle, rickshaw, van, push cart and so on.



Transportation of unpacked tomatoes in open truck

- Non-refrigerated trucks and vans are mostly used for tomato transportation from the assembly markets to the destination wholesale markets as a mixed load.
- Refrigerated vehicles are to be used for long-distance transportation from the farm/assembly markets to the distant wholesale markets for maintaining optimal quality and safety of produce.



Currently practiced transportation of tomatoes (in plastic crates) in non-refrigerated truck

- The Hortex Foundation of Bangladesh recently introduced few refrigerated vehicles (Refer Truck with tem-perature range +15 to -25°C) to carry fruits and vegetables.

4.1. Measures for transportation

- The transport vehicle should not be overloaded.
- Strong and durable packages should be used.
- Rough handling during loading and unloading should be avoided.
- Plastic liners, soft clothes or other cushioning materials should be used inside crates to minimize vibration damage.
- Adequate ventilation should be ensured to prevent heat generation.
- The crates should be aligned properly.
- Crates should be loaded in uniform stacks and braced securely.
- The entire load should be covered with light-coloured and thick canvas.



Refrigerated vehicle for long distance transportation

- Cool chain management to be ensured to maintain tomato quality.
- Delay in placing tomatoes in proper storage conditions after harvest often results in rapid deterioration in quality.
- Immediately after harvest, tomatoes are to be pre-cooled to remove field heat.
- The pre-cooling endpoint is typically 12.5°C.
- Forced air cooling is the most effective practice but room cooling is more common to remove field heat prior to storage.
- The pre-cooled tomatoes are then stored at the optimum temperature and relative humidity.
- The optimum temperature and relative humidity for storage of tomatoes are 12.5-15.0°C and 90-95%, respectively.
- Tomatoes are chilling sensitive at temperature below 10°C if held for longer than 2 weeks and at 5°C for longer than 6-7 days.



Presently practiced temporary storage of tomatoes at the wholesale market without any cooling facilities

5. Storage

- Short and long-term storage is the most important postharvest operation in horticultural supply chain.
- As a general practice, tomatoes are temporarily held in a room or shady place at ambient temperature.
- Rapid cooling of tomatoes immediately after harvest is essential for optimal postharvest keeping quality.

- Two types of temperature-induced injuries are common in tomatoes known as chilling injury and freezing injury
- Consequences of chilling injury are failure to ripen and develop full colour and flavour, irregular colour development, premature softening, surface pitting, browning of seeds and increased decay.
- Freezing injury is occurred at -1°C . Freezing injury is characterized by water soaked appearance, excessive softening, desiccated appearance of locular gel.

5.1. Measures for storage

- Tomatoes for storage need to be harvested at proper stage of maturity.
- Recommended temperature and relative humidity should be maintained.
- The storage room should not be overloaded.
- Adequate ventilation in storage rooms should be ensured.
- The storage room should always be kept clean.
- Produce should be regularly inspected to sort out the damaged produce.

5.2. Shelf life extension of tomatoes

- Modified atmosphere (MA) using various types of perforated or unperforated plastic packaging like low density polyethylene (LDPE) bags, polypropylene (PP) bags and plastic film could be used to prolong shelf life.
- MA storage in combination with low temperature is suggested for more prolonged shelf life of tomatoes.

- Hot water treatments have commercial implications on shelf life of tomatoes. The recommended temperature of hot water is $50-55^{\circ}\text{C}$ for 0.5-1.0 minute.
- Hot water dip must be precisely administered as a little higher than the above temperature may cause damage to tomatoes.



Postharvest spoilage due to lack of storage and processing facilities

6. Ripening

- Fruit ripening is an integral part of today's commercial horticulture.
- Tomato can be ripened either naturally or artificially.
- Tomato harvested at 'Pink' stage are ripened naturally with optimal taste and quality.
- However, for commercial purposes and for uniform ripening chemical ripening is also recommended.



Naturally ripened tomatoes



Artificially ripened tomatoes

- For artificial ripening, tomatoes to be harvested at ‘Breaker’ stage of maturity. Then the fruits are to be exposed to ethylene gas at a rate of 100-150 ppm for 24-48 h at 20-25°C.
- Ethylene gas is the only recommended and safe ripening agent worldwide.
- This is urgent to introduce ethylene-induced ripening technology, optimize to the local socio-economic conditions and extend thereafter to the relevant stakeholders.

7. Quality deterioration of tomato

- Tomato is highly perishable vegetable.
- Quality of tomato deteriorates quickly due to increased postharvest physiological processes (Respiration and ethylene production), water loss, desiccation, wilting and microbial infection if proper postharvest practices are not followed.
- Postharvest diseases caused by fungi and bacteria contribute to high postharvest loss.



Spoilage of tomatoes in the field due to less market price

- The most important postharvest fungal diseases are black mold and bacterial soft rot.
- Postharvest loss occurs at various stages of supply chain (Table 2).
- The principal causes of postharvest loss and quality deterioration are inadequate infrastructures for postharvest handling, increased postharvest physiological processes, sub-standard postharvest handling, microbial decay, lack of training and lack of awareness.

Table 2. Postharvest losses of tomato in traditional supply chain in Bangladesh

Supply chain actors	Postharvest loss (%)	Major causes of loss
Growers	6.9	<ul style="list-style-type: none"> ● Insect damage ● Microbial decay ● Lack of proper handling ● Improper harvesting
Collectors (Bepari)	9.1	<ul style="list-style-type: none"> ● Lack of sorting ● Improper transport vehicle ● Damaged roads and highways ● Delay in delivery ● Lack of proper packaging ● Lack of proper handling
Wholesalers	8.0	<ul style="list-style-type: none"> ● Improper handling ● Lack of sorting ● Lack of storage facilities
Retailers	8.9	<ul style="list-style-type: none"> ● Tomatoes remain unsold ● Delayed in selling ● Lack of storage facilities ● Unhygienic market conditions
Total loss	32.9	-

8. Effectiveness of Improved Practices

- In Bangladesh, improved postharvest practices are hardly followed for tomato.
- However, improved postharvest practices are to be adopted to minimize loss and maintain quality and safety in supply chain.
- Comparison of conventional and improved postharvest management practices for tomato is furnished in Table 3.

Table 3. Comparison of different technologies for postharvest handling

Postharvest procedure	Conventional technology	Improved/standard technology
Harvesting maturity for storage	'Breaker' or 'Turning' or 'Pink'. Immature fruits are also harvested followed by artificial ripening	'Breaker' or 'Pink' or 'Light red' depending on the purpose of use
Field packing container	Bamboo baskets, plastic sacks, jute sacks, plastic crates	Plastic crates
Weight of container in the field	Bamboo basket (20-40 kg) Plastic sack (20-40 kg)	Plastic crates (20-22 kg)
Pre-cooling	Ambient condition (in cool and shady place)	Mechanical pre-cooling (forced air cooling)
Sorting	Rot and size	Size, colour, quality, defect
Grading	Size	Size, colour, quality
Packaging materials	Bamboo baskets, plastic sacks, jute sacks	Plastic crates, corrugated fibreboard boxes (rigid)
Weight of packaging	Plastic sack (20-40 kg)	Plastic crates (20-22 kg)
Storage temperature and humidity	Ambient	7-15°C temperature and 90-95% RH
Transportation	Mixed load in open mini or large trucks at ambient condition	Controlled temperature in refrigerated vehicles
Ripening method	Natural ripening or liquid formulations containing ethephon as active ingredient (not yet recommended)	Ethylene gas at a rate of 100-150 ppm for 24-48 h at 20-25°C
Postharvest losses	Total loss: 33% At growers' level: 7% At collector's level: 9%	Total loss: Approx. 15% At growers' level: 2% At collector's level: 5%

9. New Improved Postharvest Technology

- Controlled atmosphere (CA) storage offer a moderate level of benefit. Low O₂ levels (3-5%) delay ripening. More typically, 3% O₂ and 0-3% CO₂ are used to maintain acceptable quality for up to 6 weeks prior to ripening.
- 1-MCP (1-methylcyclopene), an ethylene inhibiting gas, can be used to extend shelf life of tomato dramatically when exposed to 1-2 ppm for 24 hours at 20°C.
- Zero Energy Cool Chamber or earthen cooling pot can be useful to extend shelf life of tomato.